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# Characterization of adaptive and productive soybean (*G. max* L.) genotypes in dry land of Kalimantan, Indonesia

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**Abstract.** Dry land is one of potential areas for soybean (*Glycine max* L. Merrill) development. A total of 12 soybean genotypes, including two check varieties of Anjasmoro (high yield) and Demas 1 (adaptive in acidic dry land) were evaluated in two locations of dry land in Gunung Makmur Village and Kuala Tambangan Village, South Kalimantan, Indonesia from May to August 2017. The experimental design in each location was randomized block design (with 12 soybean genotypes as treatments) and four replicates. Data were subjected to combined ANOVA. The range of seed yield in Gunung Makmur was 1.56 t ha<sup>-1</sup> to 3.18 t ha<sup>-1</sup> and in Kuala Tambangan was 1.72 t ha<sup>-1</sup> to 2.96 t ha<sup>-1</sup>. Anjasmoro variety showed a higher productivity than Demas 1. Genotype of 19BE produced the highest yield in Gunung Makmur (3.18 t ha<sup>-1</sup>), meanwhile G511H/Anjs-1-3 produced the highest yield in Kuala Tambangan (2.96 t ha<sup>-1</sup>). The best genotype across environments was G511H/Anjs-1-3 (2.99 t ha<sup>-1</sup>), then followed by 19BE (2.74 t ha<sup>-1</sup>). The G511H/Anjs-1-3 has medium height and a relatively low of empty pods, meanwhile 19BE has medium height and relatively high numbers of nodes per plant and branches per plant. Those genotypes could be developed in acidic dry land area of Kalimantan.

**Keywords:** Agronomic characters, cluster analysis, G × E, seed yield

## 1. Introduction

Indonesia is one of the world's largest consumer of soybean (*G. max* L.) The average consumptions of tempeh and tofu in 2014 were 6.95 kg and 7.07 kg per person yr<sup>-1</sup>, respectively. Increasing population causes the increase in domestic soybean demand. The domestic soybean production has not been able to meet the domestic demand, hence the need to import soybeans about  $1.96 \times 10^6$  t [1]. To increase domestic soybean production, the government targets to have nearly  $1.5 \times 10^6$  ha of soybean area.

Theoretically, Indonesia has a land area of  $188.2 \times 10^6$  ha, consisting of dry land ( $148 \times 10^6$  ha) and wetland, including swamp land (peat, tidal and swampy land) and land that has become a permanent rice field. About  $148 \times 10^6$  ha of dry land can be grouped into acidic dry land ( $102.8 \times 10^6$  ha) and non-acid upland area ( $45.2 \times 10^6$  ha) [2]. Dry land has great opportunities to be developed for soybean extensification if there is availability of adaptive and productive soybean variety.

Research on some soybean varieties in dry land showed that soybean varieties of Wilis, Slamet and Tanggamus have the potential to be developed due to their good adaptation and productivity in the dry land [3]. In Midsouthern USA, Bellaloui et al. [4] develop soybean with high seed nutritional values



and high germination under dryland conditions. Another research also reported that a high heat and drought in the ESPS (Early Soybean Production System) are still major environmental stress factors, resulting in poor seed quality and yield reduction for heat sensitive soybeans, especially under dryland conditions [5, 6]. Indeed, the land psycho-chemical have become a problem on dry land, such as soil less fertile, reacted acid, contain high Al, Fe and Mn, poor in organic matter and essential macro nutrients (N, P, K, Ca and Mg) and water deficit [7].

Some efforts have been done to optimize the dry land for soybean development, such as by adding the soil conditioner. The application of chicken manure ameliorant have been reported increase the soybean yield up to 2.4 t ha<sup>-1</sup> [8]. A study using various Nitrogen sources to determine the growth analysis of several soybean genotypes in dry land obtained the combinations of *Bradyrhizobium* sp. and manure 5 t ha<sup>-1</sup> as the best treatment [9]. However, it should be note that the application of soil conditioner has an impact on the increasing costs of soybean farming and the application of soil conditioner must be carried out continuously. Thus the provision of soybean varieties adaptive to dry land are considered more advantageous than the use of soil conditioner [10, 11]. Moreover, Singh et al. [12] also stated the necessity to use resistant varieties in the improvement of genetic resistance to abiotic stresses. This is reasonable because the availability of those resistant varieties do not require additional farming costs, the effect of long-term adaptive varieties, and it is compatible with other components of soybean cultivation technology.

A screening on soybean resistance to low acid soil have been conducted for 2 yr [13]. The study obtained several acid tolerant genotypes with normal root growth and higher seed yield at pH < 5.5. Ojo et al. [14] screened 55 soybean genotypes and obtained eight acid tolerant varieties. The evaluation of several soybean genotypes in acidic dry land in Indonesia have obtained two genotypes (G4AB and G115H/Kaba//Kaba///Kaba-8-6) adaptive at pH 4.73 to 5.04 [15]. Furthermore, soybean genotype adaptive to acid soil was characterized by its ability to maintain the plant height, and followed by a high number of node per plant and pod per plant. The research aims were to identify and characterize soybean genotypes which able to produce high yield in acidic dry land of Kalimantan.

## 2. Materials and method

The field trials were conducted in two locations of dry land in South Kalimantan, namely Gunung Makmur Village and Kuala Tambangan Village (Takisung District, Tanah Laut Regency) from May to August 2017. The research materials consisted of ten soybean (*Glycine max* L. Merrill) promising lines and two check varieties, i.e. Demas 1 and Anjasmoro (table 1).

A randomized block design with twelve genotypes and four replications was used on each location. The plot size was 2.0 m × 4.5 m, 40 cm × 15 cm plant spacing, two seeds per hill. Fertilizer consisted of 250 kg ha<sup>-2</sup> Phonska, 100 kg SP 36, and 1 t ha<sup>-1</sup> organic fertilizer which applied entirely after planting. Weed control was done 2 wk and 4 wk after planting. Pest and disease was also intensively controlled.

Soil sample was collected on each location before planting. Soil sampling was done at five diagonal points and then it mixed for each location. Soil analysis consisted of actual pH (H<sub>2</sub>O), potential pH (KCl), P<sub>2</sub>O<sub>5</sub> (Bray I), exchangeable Al and exchangeable H. Observation was made on (i) plant age characters (days to flowering and days to maturity), (ii) plant growth (plant height, number of branches, number of node, number of filled pod, and number of empty pod), and (iii) seed characters (100 weight and seed yield). Data were analyzed using randomized block design over locations and cluster analysis.

**Table 1.** Genetic materials used in two locations of dry land.

No	Genotype	Source <sup>a</sup>	Remarks
1	11 AB	UNIB	Promising line
2	13 ED	UNIB	Promising line
3	14 DD	UNIB	Promising line
4	19 BE	UNIB	Promising line

Continue on next page

**Tabel 1.** Continued.

No	Genotype	Source <sup>a</sup>	Remarks
5	25 EC	UNIB	Promising line
6	G511H/Kaba//Kaba//Kaba-8-6	ILETRI	Promising line
7	G511H/Anjs//Anjs-2-10	ILETRI	Promising line
8	G511H/Anjs-1-3	ILETRI	Promising line
9	G511H/Anj//Anj//Anj-11-2	ILETRI	Promising line
10	G511H/Arg//Arg-2-1	ILETRI	Promising line
11	Demas 1	ILETRI	Released variety
12	Anjasmoro	ILETRI	Released variety

<sup>a</sup>UNIB = University of Bengkulu, ILETRI = Indonesian Legume and Tuber Crops Research Institute

### 3. Result and discussion

#### 3.1. Soil properties

Two locations of dry land which used in this study have different soil properties (table 2). Location of Gunung Makmur has pH H<sub>2</sub>O 6.1 and pH KCl 4.2, and Kuala Tambangan has pH H<sub>2</sub>O 5.8 and pH KCl 5.0. It showed that location of Kuala Tambangan was more acid than Gunung Makmur. The P<sub>2</sub>O<sub>5</sub> content in Gunung Makmur was higher than in Kuala Tambangan, whereas the Al exchangeable and H exchangeable was undetectable.

**Table 2.** Soil properties in two locations of dry land.

Location	pH	pH	P <sub>2</sub> O <sub>5</sub>	Al-dd	H-dd
	H <sub>2</sub> O	KCl	Bray I (μg g <sup>-1</sup> )	KCl 1 N	(Cmpl <sup>+</sup> kg <sup>-1</sup> )
Gunung Makmur Village, Takisung District, Tanah Laut Regency	6.1	4.2	370.00	0.4	0.8
Kuala Tambangan Village, Takisung District, Tanah Laut Regency	5.8	5.0	191.00	0.0	0.0

#### 3.2. Combined analysis of variance

The combined analysis of variance for plant age, growth and seed characters was presented in table 3. The interaction of genotype (G) and location (L) was significant for days to maturity, number of empty pod, 100 seed weight, and seed yield; indicate that genotype by environment interaction (G × L) affecting those characters. Location was significant for all characters, except number of branches, number of nodes, and number of filled pod. Genotype was significant for all characters studied, showed the characters difference on each genotype. CV value vary from 1.44 % to 39.10 % (table 2).

**Table 3.** Combined analysis of variance for yield and yield components of 12 soybean genotypes in dry land.

No	Characters	Mean square				CV (%)
		Replication R	Location (L)	Genotype (G)	L × G	
1	Days to maturity	0.0937 <sup>ns</sup>	0.5937 <sup>**</sup>	38.9573 <sup>**</sup>	4.7755 <sup>**</sup>	2.53
2	Days to flowering	1.6493 <sup>ns</sup>	14.2604 <sup>**</sup>	98.6165 <sup>**</sup>	1.7831 <sup>ns</sup>	1.44
3	Plant height	169.7262 <sup>ns</sup>	915.3202 <sup>**</sup>	238.2238 <sup>**</sup>	82.8571 <sup>ns</sup>	15.29
4	Number of branches	1.1748 <sup>*</sup>	0.8085 <sup>ns</sup>	1.8303 <sup>**</sup>	0.4733 <sup>ns</sup>	25.17
5	Number of nodes	103.3521 <sup>ns</sup>	0.0001 <sup>ns</sup>	121.6175 <sup>**</sup>	108.7895 <sup>ns</sup>	39.10
6	Number of filled pod	318.6465 <sup>ns</sup>	224.5122 <sup>ns</sup>	239.9915 <sup>**</sup>	192.1885 <sup>ns</sup>	28.92
7	Number of empty pod	16.1353 <sup>ns</sup>	1148.5817 <sup>**</sup>	30.6788 <sup>**</sup>	33.4072 <sup>**</sup>	20.23
8	100 seed weight	0.5577 <sup>ns</sup>	94.4066 <sup>**</sup>	23.5993 <sup>**</sup>	2.9521 <sup>**</sup>	3.86
9	Seed yield	0.6086 <sup>**</sup>	0.2784 <sup>*</sup>	0.9429 <sup>**</sup>	0.2786 <sup>**</sup>	13.23

Notes: CV = coefficient of variation; ns = not significant; \* = significant at p = 0.05; \*\* = significant at p = 0.01

### 3.3. Characters of days to maturity

In Indonesia, plant age is become important character due to soybean is cultivated three times a year in various agro ecosystem. The days to flowering was varied between genotypes as well as locations. The average of days to flowering in Gunung Makmur and Kuala Tambangan was 31 d (table 4). The range of days to flowering in Gunung Makmur was 28 d to 34 d, whereas in Kuala Tambangan was 28 d to 34 d.

The average of days to maturity in two locations was almost equal, i.e. 80 d and 81 d in Gunung Makmur and Kuala Tambangan, respectively (table 3). The days to maturity in Gunung Makmur ranged from 76 d to 84 d. The check variety of Demas 1 has medium maturity (84 d), and several genotypes has early maturity (76 d to 78 d). In Kuala Tambangan, the days to maturity ranged from 76 d to 85 d. In this location was also obtained five genotypes with days to maturity under 80 d, which was categorized in Indonesia as early maturity.

**Table 4.** Days to flowering and days to maturity of 12 soybean genotypes in dry land.

No	Genotype	Days to flowering (d)			Days to maturity (d)		
		GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$
1	11 AB	33	32	33	83	83	83
2	13 ED	28	34	31	83	86	85
3	14 DD	30	31	31	83	83	83
4	19 BE	29	28	29	81	83	82
5	25 EC	29	29	29	82	85	84
6	G511H/Kaba//Kaba//Kaba-8-6	29	29	29	78	79	79
7	G511H/Anjs//Anjs-2-10	30	31	31	76	76	76
8	G511H/Anjs-1-3	34	34	34	78	78	78
9	G511H/Anj//Anj//Anj-11-2	28	28	28	76	77	77
10	G511H/Arg//Arg-2-1	30	30	30	76	76	76
11	Demas 1	34	34	34	84	85	85
12	Anjasmoro	34	34	34	83	83	83
Average		31	31	31	80	81	81

GMK = Gunung Makmur Village, KTB = Kuala Tambangan Village,  $\bar{x}$  = average

### 3.4. Plant growth characters

The plant growth characters in this study consisted of plant height, number of branches, number of nodes, and number of filled and empty pods (table 5 and table 6). The average of plant height in Kuala Tambangan (61.33 cm) was higher than in Gunung Makmur (56.44 cm), but the average number of branches in Gunung Makmur (2.82 branches per plant) was over than Kuala Tambangan (2.63 branches per plant). However, the number of nodes was similar between two locations, i.e. 19.79 nodes per plant.

Other plant growth characters, namely number of filled and empty pod were presented in table 5. Number of filled pod in Gunung Makmur (48.25 filled pods per plant) was more than in Kuala Tambangan (43.86 filled pod per plant), but on the contrary, number of empty pods in Gunung Makmur (4.28 empty pods per plant) was less than in Kuala Tambangan (10.85 empty pods per plant).

**Table 5.** Plant height, branches number, and nodes number of 12 soybean genotypes in dry land.

No	Genotype	Plant height (cm)			Number of branches per plant			Number of nodes per plant		
		GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$
1	11 AB	53.73	45.50	49.62	2.13	2.08	2.10	17.42	13.58	15.50
2	13 ED	64.25	64.34	64.29	2.83	2.92	2.88	20.00	20.25	20.13
3	14 DD	54.84	65.33	60.08	3.33	3.00	3.17	20.92	20.59	20.75
4	19 BE	53.92	56.67	55.29	3.17	3.25	3.21	22.34	20.59	21.46
5	25 EC	50.75	68.75	59.75	3.00	3.42	3.21	19.09	40.25	29.67

Continue on the next page

**Tabel 5.** Continued.

No	Genotype	Plant height (cm)			Number of branches per plant			Number of nodes per plant		
		GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$
6	G511H/Kaba//Kaba//Kaba-8-6	64.33	74.92	69.63	2.42	2.25	2.33	17.92	18.50	18.21
7	G511H/Anjs//Anjs-2-10	64.00	59.67	61.83	2.75	2.00	2.37	21.00	15.67	18.33
8	G511H/Anjs-1-3	54.75	51.75	53.25	2.17	2.25	2.21	20.50	14.50	17.50
9	G511H/Anj//Anj//Anj-11-2	49.34	57.84	53.59	2.67	2.17	2.42	18.17	15.50	16.83
10	G511H/Arg//Arg-2-1	53.34	58.42	55.88	2.92	1.83	2.38	18.75	12.92	15.83
11	Demas 1	64.17	71.67	67.92	3.25	3.83	3.54	20.92	25.92	23.42
12	Anjasmoro	49.92	61.09	55.50	3.17	2.58	2.87	20.50	19.25	19.88
Average		56.44	61.33	58.89	2.82	2.63	2.72	19.79	19.79	19.79

GMK = Gunung Makmur Village, KTB = Kuala Tambangan Village,  $\bar{x}$  = average**Table 6.** Number of filled and empty pods of 12 soybean genotypes in dry land.

No	Genotype	Number of filled pod per plant			Number of empty pod per plant		
		GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$
1	11 AB	40.38	41.59	40.98	3.02	12.50	7.76
2	13 ED	53.00	41.17	47.08	2.50	15.50	9.00
3	14 DD	52.83	47.92	50.38	9.58	13.08	11.33
4	19 BE	46.75	44.42	45.58	3.17	13.08	8.13
5	25 EC	51.83	62.67	57.25	2.50	13.83	8.17
6	G511H/Kaba//Kaba//Kaba-8-6	46.33	46.09	46.21	1.33	9.42	5.37
7	G511H/Anjs//Anjs-2-10	49.75	36.50	43.12	3.34	9.34	6.34
8	G511H/Anjs-1-3	45.75	37.17	41.46	4.84	6.00	5.42
9	G511H/Anj//Anj//Anj-11-2	47.59	34.25	40.92	5.08	8.67	6.87
10	G511H/Arg//Arg-2-1	49.59	36.84	43.21	5.08	5.34	5.21
11	Demas 1	47.17	48.17	47.67	4.84	10.59	7.71
12	Anjasmoro	48.09	49.59	48.84	6.08	12.83	9.46
Average		48.25	43.86	46.06	4.28	10.85	7.56

GMK = Gunung Makmur Village, KTB = Kuala Tambangan Village,  $\bar{x}$  = average

### 3.5. Seed characters

Seed characteristics, especially seed yield, is a complex character which determined by various plant age and growth attributes. The average of seed size in Gunung Makmur (15.05 g per 100 seeds) was higher than in Kuala Tambangan (13.07 g per 100 seeds). The similar pattern also showed in seed yield, i.e. location of Gunung Makmur (2.48 t ha<sup>-1</sup>) produce higher yield than location of Kuala Tambangan (2.37 t ha<sup>-1</sup>) (table 7).

Based on seed size average of two locations, genotype G511H/Arg//Arg-2-1 has larger size (17.40 g per 100 seeds) than others. The highest yield was produced by G511H/Anjs-1-3 (2.99 t ha<sup>-1</sup>), followed by 19BE (2.74 t ha<sup>-1</sup>). The check variety of Demas 1 (1.64 t ha<sup>-1</sup>) was less productive than Anjasmoro variety which produce 2.16 t ha<sup>-1</sup>.

### 3.6. Grouping of genotypes

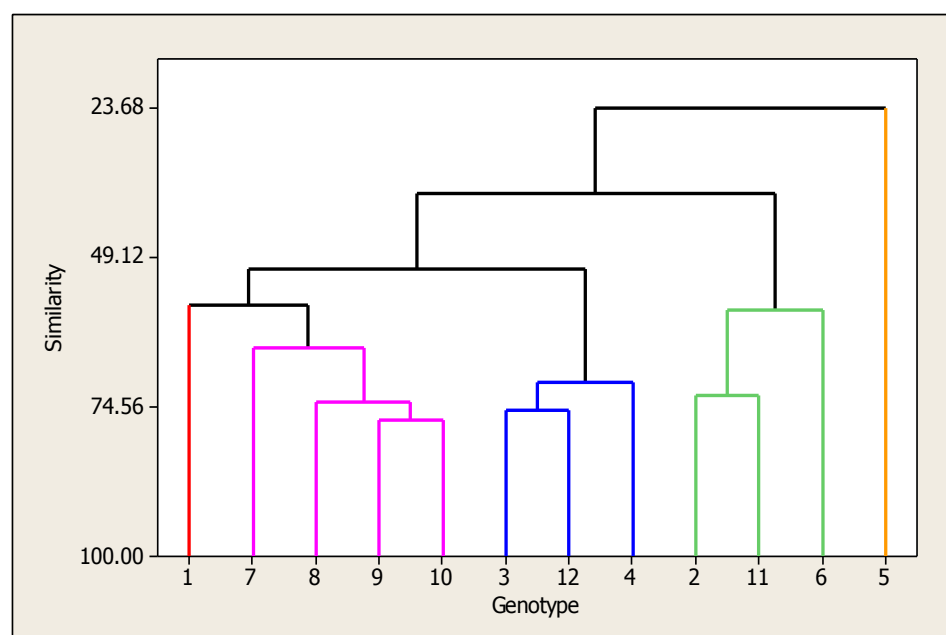
Grouping of soybean genotypes was using the average of all characters from two locations (figure 1). Based on cluster analysis, it was grouped into five clusters, namely cluster I (one genotype) cluster II (four genotypes), cluster III (three genotypes), cluster IV (three genotypes), and cluster V (one genotype). Cluster I was characterized by relatively short plant and a few number of branches and nodes. Cluster II was characterized by early maturity and relatively high yield. Genotypes in cluster III have high number of branches. Cluster IV was characterized by relatively great height. Furthermore, cluster V has the highest number of nodes and number of filled pods. The highest-yield genotype in two locations (G511H/Anjs-1-3) has similarly agronomic characteristics with G511H/Anj//Anj//Anj-11-2 and Anjasmoro. The best next genotype was 19 BE which has similarly agronomic characteristics

with 14DD and Anjasmoro. Thus, genotypes which located in cluster II and III can be considered as gene source for improving soybean adaptation in dry land. Meanwhile, G511H/Anjs-1-3 and 19BE can be recommended to be developed in dry land.

**Table 7.** The weight of 100 seed and seed yield of 12 soybean genotypes in dry land.

No	Genotype	100 seed weight (g)			Seed yield (t ha <sup>-1</sup> )		
		GMK	KTB	$\bar{x}$	GMK	KTB	$\bar{x}$
1	11 AB	15.60	14.10	14.85	2.72	2.51	2.61
2	13 ED	14.20	12.10	13.15	2.59	2.03	2.31
3	14 DD	14.60	11.70	13.15	2.54	2.37	2.46
4	19 BE	15.00	12.50	13.75	3.18	2.30	2.74
5	25 EC	15.20	12.20	13.70	2.37	2.27	2.32
6	G511H/Kaba//Kaba//Kaba-8-6	16.30	13.20	14.75	2.25	2.13	2.19
7	G511H/Anjs//Anjs-2-10	17.20	14.50	15.85	2.37	2.75	2.56
8	G511H/Anjs-1-3	16.30	12.70	14.50	3.01	2.96	2.99
9	G511H/Anj//Anj//Anj-11-2	14.50	13.30	13.90	2.51	2.82	2.67
10	G511H/Arg//Arg-2-1	17.70	17.10	17.40	2.66	2.30	2.48
11	Demas 1	10.00	10.50	10.25	1.56	1.72	1.64
12	Anjasmoro	14.00	12.90	13.45	2.01	2.30	2.16
Average		15.05	13.07	14.06	2.48	2.37	2.43

GMK = Gunung Makmur Village, KTB = Kuala Tambangan Village,  $\bar{x}$  = average



**Figure 1.** Grouping of 12 soybean genotypes based on agronomic characters.

### 3.7. Discussion

Strategy for increasing national soybean production can be done through intensification of lowland or upland in Java Island, or extensification to outside area of Java Island. The availability of land area outside Java Island is still large, especially dry land. However, efforts to expand the area outside Java is have to deal with soil psycho-chemical problems, such nutrition imbalance and drought stress. The most ideal approach to optimize the use of dry land (both acid and non-acidic) outside of Java is by providing soybean varieties adaptive to dry land. Furthermore, genetic improvement of soybean for abiotic stress is an economically feasible option [16].

Various studies have shown the existence of the genotype by environment interaction [17, 19-21], which suggests a specific adaptation of each soybean genotype to particular environments. In this study also obtained the genotype by environment interaction for days to flowering, number of empty pod, 100 seed weight, and seed yield. As implication, the best genotype in Gunung Makmur was 19BE, and followed by G511H/Anjs-1-3 and 11AB. Meanwhile, the best genotype in Kuala Tambangan was G511H/Anjs-1-3, followed by G511H/Anj//Anj///Anj-11-2 and G511H/Anjs//Anjs-2-10. There was changing in the superiority rank among two locations, due to the existence of the genotype by environment interaction

The characteristics of the study sites, i.e. the location of Gunung Makmur has pH of 6.1 and Kuala Tambangan has pH 5.8. The average seed yield in Gunung Makmur was  $2.48 \text{ t ha}^{-1}$ , whereas in Kuala Tambangan was  $2.37 \text{ t ha}^{-1}$ . The soil pH seems to be correlated with soybean productivity. Adie & Krisnawati [15] reported that the lower soil pH will decrease the soybean productivity. Kuswanto & Zen [22] screened soybean genotypes at pH  $\text{H}_2\text{O}$  4.3, exchangeable-Al 3.92 mL eq per 100 g, and Al saturation 56.48 %, and obtained two tolerant genotypes at those environments. Furthermore, in Nigeria, the soybean characteristics which tolerant to  $\text{pH} < 5.5$  were characterized by root system capability. Manassila et al. [23] using approach of adaptive acid tolerance response (ATR), to investigate the role of protein in acid tolerance or adaptive acid tolerance.

Soybean yield is a complex characters which constitute by various agronomic traits [24–26]. In this study, the decrease in soil pH decreases some agronomic characters, namely the number of branches, the number of pods, the seed size, and yield. Conversely, decreasing soil pH increases the character of plant height and number of empty pods. A study by Kuswanto [18] reported that soybean genotype which able to maintain the high number of filled pods showed good adaptation to acidic dry land. Another study about soybean response to three water treatments showed that water stress affected plants by reducing the number of flowers produced, the leaf surface area as well as the relative leaf water content [27]. A study in chickpea showed that root length density, total root dry weight, deep root dry weight and root-shoot ratio were found to be associated with tolerance to water stress environment [28]. On soybean, root characteristic have improve drought avoidance by increasing water uptake from the soil profile [29]. An optimal root system will have an implication on the upper ground of agronomic characters. A high productivity of genotype was generally have good agronomic performance. The plant height of the two best genotypes were about 54 cm, and the number of pods per plants were 45 pods, respectively.

The check varieties which used in this study were Anjasmoro and Demas 1. The characteristics of Anjasmoro are large seed size and pod shatter resistant, whereas Demas 1 is soybean adaptive to acidic dry land which had released in 2014. The performance of those two varieties in acidic dry land of Kalimantan were not optimal. In fact both were only able to produce below the average yield of all tested genotypes. Nowadays, Anjasmoro has widely spread, especially in dry land. Based on the dendrogram of agronomic characters (Figure 1), it showed that the highest yielding genotype has similarity characters with Anjasmoro. Thus it provide wide opportunity to be accepted by farmers

#### 4. Conclusion

Soybean productivity in dry land was potential to increase by providing soybeans adaptive to dry land. The use of those cultivars do not affect the agronomic characters, such as plant age, seed size and yield. Soybean genotypes G511H/Anjs-1-3 and 19BE were potentially be developed in acidic dry land, especially in Kalimantan.

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<http://epublikasi.setjen.pertanian.go.id/epublikasi/outlook/2015/Tanaman%20Pangan/Outlook%20Kedelai%202015/files/assets/common/downloads/Outlook%20Kedelai%202015.pdf>
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